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Marine turtle interaction with purse-seine fishery in the Atlantic and Indian oceans: Lessons for management

Jérôme Bourjea [a,*,1], Sandra Clermont [a,b,c], Alicia Delgado [d], Hilario Murua [e], Jon Ruiz [e], Stéphane Ciccione [b], Pierre Chavance [f,*]

[a] IFREMER, Institut Français de Recherche pour l'Exploitation de la Mer, Délégation de La Réunion, Rue Jean Bertho, BP 60, 97 822 Le Port Cedex, La Réunion, France
[b] KELONIA, l'observatoire des tortues marines de La Réunion, 46 rue du Général De Gaule, 97 436 Saint Leu, La Réunion, France
[c] AgroParisTech, Institut des sciences et industries du vivant et de l'environnement, 16 rue Claude Bernard F-75231, Paris Cedex 05, France
[d] IEO, Instituto Español de Oceanografía, Vía Espaldón, Darsena Pesquera, PCL 8, 38180 Santa Cruz de Tenerife, Spain
[e] AZTI Tecnalia, Unidad de Investigación Marina, Herrera kaia portualdea z/g, Pasaia, Gipuzcoa, Spain
[f] IRD, Institut de Recherche pour le Développement, Avenue Jean Monnet, CS 30171, 34203 Sète, Cedex, France

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ABSTRACT

Bycatch of endangered marine turtles is a growing issue for the management of all fisheries, including the oceanic purse-seine fishery. The aim of this study was to assess the spatial and temporal variation in bycatch rates of these species in the entire European purse-seine fishery operating in the Atlantic and Indian oceans. The study was based on data collected through observer programs from 1995 to 2011. During that period, a total of 15 913 fishing sets were observed, including 6 515 on Drifting Fish Aggregating Devices (DFADs) and 9 398 on free swimming schools, representing a global coverage of 10.3% and 5.1% of the total fishing activity in the Atlantic and Indian Ocean, respectively. Moreover, from 2003 to 2011, 14 124 specific observations were carried out on DFADs to check turtle entanglement in the net covering DFADs. We found that the purse-seine fishery has a very low impact on marine turtles. We estimated that the annual number of individuals incidentally captured was 218 (SD = 150) and 250 (SD = 157) in the Atlantic and Indian Ocean, respectively, with more than 75% being released alive. The present study also investigated the impact of DFADs; which is considered a key conservation issue for this fishery. Drifting objects may play a key role in aggregating juveniles of marine turtles, implying the need for improving their construction to avoid entanglement (e.g. avoiding nets in the structure); however, based on our study it is not the main source of incidental captures of marine turtles in this fishery.

1. Introduction

Marine ecosystems are extensively affected by human activities and require urgent implementation of management and conservation measures for marine resources (Halpern et al., 2008). The environmental and economic concerns about the impacts of fisheries on these ecosystems and associated marine populations are growing. Fisheries can alter habitats, and disturb the community structure by increasing mortality and modifying the population composition which consequently, may affect the whole ecosystem (Jenning and Kaiser, 1998; Hall et al., 2000; Jackson et al., 2001; Pauly et al., 2005). Bycatch, *i.e.* the incidental catch of undesirable size or age classes of the target species (e.g. juveniles), or the incidental catch of other non-target species (Lewison et al., 2004) has such negative impact. Large marine vertebrates, such as marine turtles, marine mammals and seabirds, with little or no commercial value, accidentally interact with a large range of fishing gears, resulting in injury or possible individual death (Hall et al., 2000). However, assessing the real impact of bycatch on large marine vertebrate populations is challenging. Sea turtle bycatch tends to be a relatively rare event, with most observed fishing sets containing zero bycatch, and most events clustered within the relatively few sets that overlap animal aggregations (Sims et al., 2008).

Six of the seven marine turtle species are listed as Vulnerable, Endangered or Critically Endangered on the IUCN Red List (www.iucnredlist.org; accessed 30 July 2012). Marine turtles are captured in most of fishing gears (Alverson et al., 1994) but little is known about the real level of associated mortality. The long

* Corresponding authors. Tel.: +262 262 42 03 40; fax: +262 262 43 36 84.
E-mail addresses: jerome.bourjea@ifremer.fr (J. Bourjea), sandra.clermont@agroparistech.fr (S. Clermont), alicia.delgado@ca.ieo.es (A. Delgado), hmurua@azti.es (H. Murua), jruiz@azti.es (J. Ruiz), stephaneciccione@kelonia.org (S. Ciccione), pierre.chavance@ird.fr (P. Chavance).
[1] Tel.: +262 (0) 692 65 62 96.

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oceanic migration of most marine turtles (see review in Luschi, 2013) leads them to interact with open ocean fisheries worldwide; however, the lack of global understanding of the movement between the successive habitats and the level of interactions with fisheries preclude the implementing of appropriate management measures to significantly reduce fisheries related mortality. A need of a "region-gear" combination that warrant urgent conservation measures needs to be adopted.

Tuna (or swordfish) drifting longline fishery, the drifting gillnet fishery and the oceanic purse-seine fisheries are among the most economically valuable open sea fisheries in the Atlantic and Indian oceans. In both oceans, information is available regarding interaction with marine turtles for both longline and gillnet fisheries (see Hall et al., 2000; Lewison et al., 2004; Moore et al., 2009; Wallace et al., 2008, 2010; Lewison et al., 2014), but little is currently published regarding the real impact of the purse-seine fishery on marine turtles. In 2012 the fishery recorded around 307 000 tons of tuna in the Atlantic and 356 000 tons Indian Ocean and is dominated largely by the European Union (EU) fleets composed of Spanish and French vessels. The purse-seine fishing technique consists of surrounding the tuna school with a purse-seine net either on a Free Swimming School (FSC) or on a school aggregated under a floating object, called a Drifting Fish Aggregating Device (DFAD; Fonteneau et al., 2013). This technique may negatively impact biodiversity (Dagorn et al., 2013).

Although tuna purse-seine fisheries have been shown to be more selective than other fisheries (Alverson et al., 1994), several species, including vulnerable and sensitive species can be incidentally caught (e.g. Amandè et al., 2010). Many reports and other grey literature sources have already implied that the purse-seine fishery has few interactions with marine turtles in three major oceans (see review in Hall and Roman, 2013). However with low observer coverage and encounters usually less than 1 percent of sets, it is difficult to produce solid estimates of sea turtle mortality that can be attributed to the purse-seine fishery (Sánchez et al., 2007; Hall and Roman, 2013). In fact, marine turtle bycatch may appear to be a rare event in most fisheries because marine turtles do not follow the assumptions most commonly used that discards are proportional to catch or to effort, and depend on environmental conditions and fishing methods (Rochet and Trenkel, 2005; Amandè et al., 2012). Such environmental dependence is particularly noticeable in the case of interaction between marine turtles and the purse-seine fishery because of (1) the oceanic range of purse-seine fishing operation (IOTC-SC15, 2012), (2) the complex life cycle of marine turtles (Miller, 1997), (3) their great migratory capability (Luschi, 2013), and (4) the lack of knowledge about the pelagic phases of those species.

In order to identify the key issues related to purse-seine fishery interaction with marine turtles, the present paper focuses on the description of interactions between marine turtles and the European purse-seine fishery in the Atlantic and Indian oceans using 15 years of data from at-sea Spanish and French observer programs.

2. Materials and methods

2.1. Datasets

Under the European Data Collection Regulations (Council Regulation no. 1543/2000, Commission Regulation no. 1581/2004, Council Regulation no. 199/2008, and Commission Decision 2008/949/EC), the European Union established a mandatory sampling program to estimate the amount of bycatch and discards in the European Union fisheries. The French (Institut de Recherche pour le Développement – IRD) and Spanish (AZTI Tecnalia and Instituto Español de Oceanografía – IEO) research institutes collaborated to implement a common framework for collecting and analysing the data from observer programs conducted on the tropical tuna purse-seine fisheries operating in the Atlantic and Indian oceans. The observers were opportunistically placed onboard purse seiners vessels in order to cover equally the four quarters of fishing activity. The observers collected information of fishing activities, target species catches, amount of bycatches by species and size frequencies of bycatches. The information collected by observers is introduced in a common database from which the data presented in this paper were extracted (e.g. Chavance et al., 2012; for more details contact authors). Spain and France started their cooperative observer programs in 2003 and in 2005 respectively. Moreover, data from other past observer programs implemented by each country and based on the same methodology were also included in the database and analysed here (Table 1).

Although observer programs before the implementation of European Union Data Collection Regulation were slightly different, these historical programs were all conducted under the International Commission for the Conservation of Atlantic Tunas (ICCAT) aegis or within European project (Table 1). Observation protocols were developed focusing on the same objective (*i.e.* estimation of bycatch) and were implemented simultaneously by the different institutes. Data from these different programs were then aggregated. Pianet et al. (2000) showed that Spanish and French purse-seiner use similar technology and have similar fishing strategy. Catches by species and by size category are not different between countries when fishing in the same strata defined by large statistical areas, quarters and fishing modes (free school set vs. Fish Aggregating Device sets). Therefore, we assume that there are no significant differences in the level of interaction with marine turtles between both fleets and between vessels. Finally, as both countries share the same observer programs and observer training technics since their implementation, we assume that errors due to the numerous different observers were similar from both French and Spanish observer programs.

Moreover, French and Spanish Purse-seine fishing activities (FSC vs. DFADs) made available 100% coverage of logbook databases for this study and for all years analysed.

2.2. Data collection

Data are collected by observers on an exact position basis (latitude and longitude) and aggregated for the analysis by 1° statistical square when needed. Observers collected the data during observer trips when a fishing set is carried out and when a drifting object is visited. Observations on sets give information on turtle bycatch during a set on Free Swimming School (FSC) or Drifting

Table 1
Periods where French and Spanish observer programs were actives and from which database the data were extracted for this study.

Observer programs	France		Spain	
	Period	Institute involved	Period	Institute involved
Associated Fauna	1995–1996	IRD[a]	1995	IEO
ICCAT[b] Bigeye Year	1998–1999	IRD	1997–1999	IEO
ICCAT Moratorium	1997–2005	IRD		IEO
EU DCR[c]	2005–2011	IRD	2003–2011	AZTI[e] and IEO[f]
TAAF[d]	2009–2011	TAAF and IRD	–	–

[a] Institut de Recherche pour le Développement.
[b] The International Commission for the Conservation of Atlantic Tunas.
[c] European Union Data Collection Framework.
[d] Terres Australes et Antarctiques Françaises.
[e] Tecnalian Unidad de Investigación Marina.
[f] Instituto Español de Oceanografía.